a titanium alloy foil having a uniform thickness of about 0.008 to about 0.015 inches.

The laminated airfoil is formed by preshaping the metallic foil. This may be conveniently done by superplastic forming, which is accomplished under stress at elevated temperature. The preshaped metallic foil having a thickness of from 0.005-0.015 inches is then trimmed to a predetermined size by conventional cutting or trimming techniques. The metallic foil and a heat flowable elastomeric film are then assembled into an assembly of alternating layers of each material and placed into a die. The die has a cavity which accepts the foil assembly and may also accept a metal leading edge sheath. The die cavity is further designed so that the final part produced will be a net shape or near net shape airfoil. The assembly, when placed into the die cavity, has a metallic foil first layer and last layer, so that the outer surfaces of final part are metal. After placing the assembly into the die, sufficient heat and pressure are applied to the ply assembly to cause the elastomeric film to flow by conventionally die pressing the assembly. This operation causes the elastomeric film to simultaneously bond to the alternating metal layers and to cure.

After removal of the cured airfoil from the die, subsequent finishing operations, such as drilling of dovetail root flank holes and insertion of high strength metal members coated with adhesive, final machining of the dovetail root section, final trimming, if necessary, and attachment of a leading edge sheaths, if not accomplished during die pressing, may be performed.

The present invention permits the use of alternating plies of materials to form airfoils, such as fan blades, and in particularly, wide chord fan blades, as well as compressor vanes. The advantages of airfoils formed in this manner is that they are lighter in weight than conventional airfoils, but retain strength and toughness required for such demanding applications. The reduced weight becomes more important in jet engine design as engines become larger and more powerful, requiring ever larger fans and vanes.

Other features and advantages of the present invention will be apparent from the following more detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention itself, however, both as to its organization and its method of practice, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. **1** is a perspective view of a fan blade airfoil having a dovetail root section and a metal sheath leading edge.

FIG. **2** is a cross section of an elastomeric layer in which a polyurethane film is coated on each side with an adhesive layer or alternatively, a combined elastomeric adhesive.

FIG. **3** is a partial cross-section of a laminated blade having alternating layers of metallic foil, elastomeric material and polymeric composite ply.

FIG. **4** is a perspective view of a fan blade airfoil having a dovetail root, a metal tip cap, a metal leading edge and an abrasive tip applied to the metal tip cap.

DETAILED DESCRIPTION OF THE INVENTION

Pursuant to the present invention, a laminated airfoil having alternating layers of a metallic foil and lightweight film, with the metallic foil forming the first layer and the last layer so that the outer surfaces of the airfoil are metal is provided.

The present invention also encompasses methods for forming laminated airfoils from metallic foils and energy-absorbing elastomeric films or polymeric composite materials and combinations thereof. The energy-absorbing elastomeric films provide impact resistance and vibration damping to the composite blades, which is an important feature in preventing blade damage due to foreign object ingestion and fatigue.

Referring now to FIG. **1**, a perspective view of the laminated airfoil in the form of the wide chord fan blade **10** is shown. The fan blade has a tip portion **12**, dovetail root section **14**, a leading edge **16** extending from the tip portion **12** to the root section **14**, a trailing edge **18** oppositely disposed to the leading edge **16** and extending from the tip portion **12** to the root section **14**. The fan blade has a metal sheath **20** attached to the leading edge **16**, apertures **22** extending through the flank surfaces **24** of the dovetail root section **14** and a high strength metal member **26** disposed through each dovetail root section aperture **22**. The metal sheath **20** attached to the leading edge helps provide the fan blade with additional impact resistance, erosion resistance and improved resistance of the composite structure to delamination. The high strength metal member **26** improves delamination resistance and provides a wear resistant surface for the dovetail, which has some restricted movement in the dovetail slot of the rotor or fan disk. The metal member **26** also improves the compressive strength of the dovetail flank by becoming the primary load bearing portion of the composite fan blade. This feature of the metal member is significant since forces in the dovetail region are high during engine operation. The stresses in the fan blade due to rotation have components radially outward as well as axial. These stresses are sufficient to cause a fan blade without a stress-bearing metal member to flow outwardly and deform, resulting in potential blade separation from the disk or delamination of the composite. The fan blade is composed of alternating layers of metallic foil **28** and energy-absorbing elastomeric layers **30** forming the laminated composite fan blade **10** of FIG. **1**. The metallic foil **28** forms the first and last layers of the alternating layers so that the outside surface of the fan blade **10** is metal.

The metallic foil may be any metallic foil suitable for use in aircraft engine applications. It is preferred that the metallic foil be selected from a group consisting of titanium alloys, nickel-base superalloys or stainless steels. It is preferred that the metallic foil be produced by superplastic forming. Superplastic forming is well known in the art. The superplastic forming method subjects certain metals which exhibit superplastic behavior to a low strain rate at high temperatures. Under these conditions, the metals can undergo unusually large amounts of plastic deformation, so that thin metallic films may be formed.